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FINITE ELEMENT ANALYSIS OF SCATTERING FROM 2D-OBJECTS OF ARBITRARY COMPOSITION

A.M. Lebedev

Russian Academy of Sciences, Institute for Theoretical and Applied Electromagnetics,
125412, ITAE, Izhorskaya 13/19, Moscow, Russia
E-mail: lebedev_am@mail.ru, lebedev@eldyn.msk.ru

ABSTRACT

A number of techniques suggested for numerical analysis of scattering from 2D-objects with complex border shape and/or arbitrarily changing electromagnetic parameters (for brevity, from 2D-objects of arbitrary composition) is very large indeed, even if to take into account only the approaches based on finite element method (MFE). Nevertheless, some methodological and "technological" questions of MFE application have been under consideration ever since first implementations of the method. The task of correct field behavior description near the border, where the electromagnetic parameters change abruptly, belongs to the first group of questions. The convenient means of problem statement, such as specification of scattering object geometry and its electromagnetic parameters variation, is an important "technological" task.

The aim of this paper is to present the MFE-based numerical procedure to evaluate the RCS signature of 2D-objects of arbitrary composition, including dielectric, metal and plasma-like objects. The scattering of waves of two polarizations (H-wave with E_z , $H_{r,\varphi}$ components, and E-wave with H_z , $E_{r,\varphi}$ components) is calculated. The original variants of solutions to the two above-mentioned questions were implemented: the weighted residual minimization type condition is implemented on the border of scattering object in order to achieve the continuity of tangential to the border field components, and AutoCAD is used for data input.

CHARACTERISTIC FEATURES OF THE NUMERICAL PROCEDURE

Wave equations for E_z or H_z components are solved with the nodal FE. The objects with arbitrary cross sections are placed inside the rectangular region, where the MFE is used. The rectangularity permits a simple adjustment of the mesh with respect to the objects' borders.

The AutoCAD possesses the convenient user's interface; it is widely used in industry. That is why AutoCAD was chosen for inputting data on the geometry of the problem and electromagnetic parameters distribution. The borders of objects are outlined with

cubic spline $\vec{r}(u) = \vec{\alpha}_0 + \vec{\alpha}_1 \cdot u + \vec{\alpha}_2 \cdot u^2 + \vec{\alpha}_3 \cdot u^3$, where $\vec{\alpha}_i = \begin{pmatrix} \alpha_{ix} \\ \alpha_{iy} \end{pmatrix}$, $i = 0 \div 3$; the

electromagnetic parameters can either be set analytically or as a surface $z(x, y)$ above the cross section. The data are read from AutoCAD output file, and then the mesh is

adjusted with the use of parametrical object's border representation. see the examples of AutoCAD drawing and automatically generated mesh in Fig1 a.b).

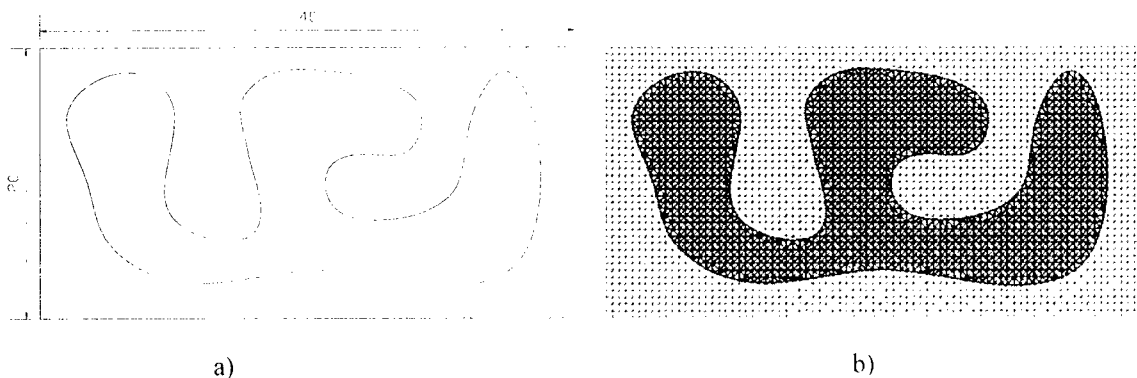


Fig.1

The distribution of E_z or H_z is found as a solution of the problem. In comparison with the known edge-based finite element technique [1] the reduction of resulting SLAE order is achieved, while the process of SLAE creation is simpler.

The question of the tangential field component (H_t for H-wave or E_t for E-wave) on the border of two media is solved by the corresponding boundary condition imposition, analogously to [2], but again with respect to the only z -component of the field. Generally the equation of SLAE has the form $R_1 + \alpha \cdot R_2 = 0$, where R_1 and R_2 are the weighted residuals, corresponding to satisfying wave equation and tangential field component continuity on the border of two media, α is a coefficient. The calculated field distributions for plane H and E-wave diffraction by dielectric cylinder with $\epsilon = 4$, $k_0 r = 3$ are shown in Fig.2, where the direction of incidence is indicated with arrows. The solution very close to reference eigen function solution can be obtained in wide range of α here - in case of E-wave. The criterion of the best choosing α is under investigation now.

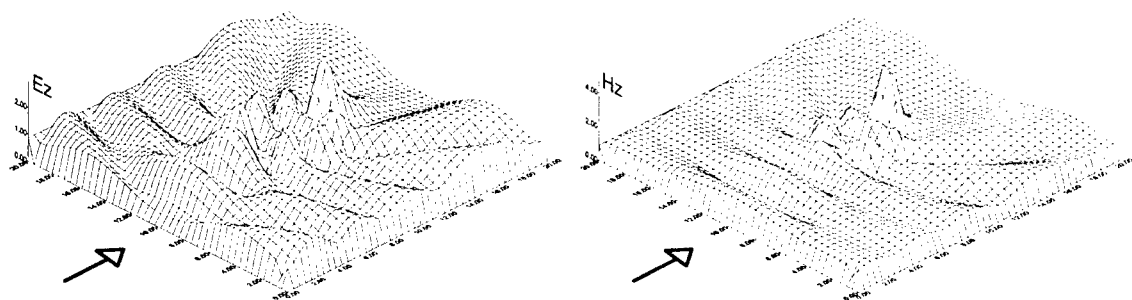


Fig. 2

The other features of the procedure are quite traditional for finite methods: the absorbing boundary conditions are imposed upon the scattered field at the mesh border, the scattering diagram is calculated with the Kirchhoff's formula and from the assumption of far zone observation point location [3].

There exists an opportunity of immediate visualization of field distribution within the calculation area, because such a distribution is just the output of wave equation solution.

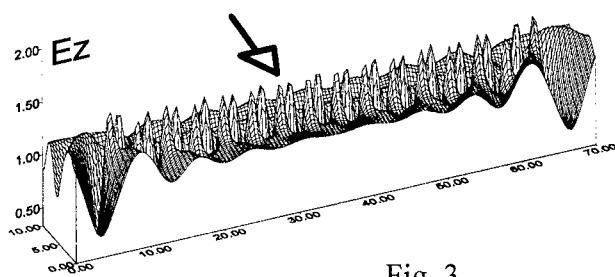


Fig. 3

distribution within the slab resulting from interaction between going through and transversal standing waves, can be seen.

The backscattering RCS pattern of $k_0 l = 60$ ($\approx 10\lambda_0$) metal plate, calculated in H-wave case, is presented in Fig.4.

The advantages of the above-described procedure are its universality, the simplicity of interface, the opportunity to introduce the inhomogeneous media.

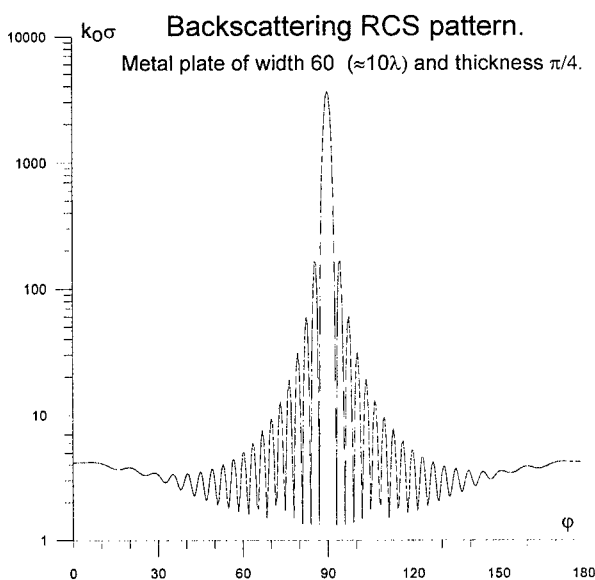


Fig. 4

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